# RF Summary

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# Outline

- Introduction
- RF cavity status
- RF power issues
- RF control and monitoring
- Testing issues
- Schedule
- Summary

# Introduction

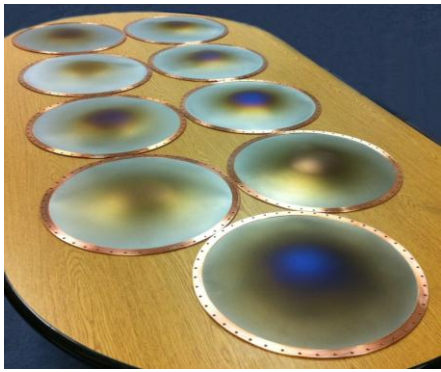
- RF system required for Steps 5 and 6

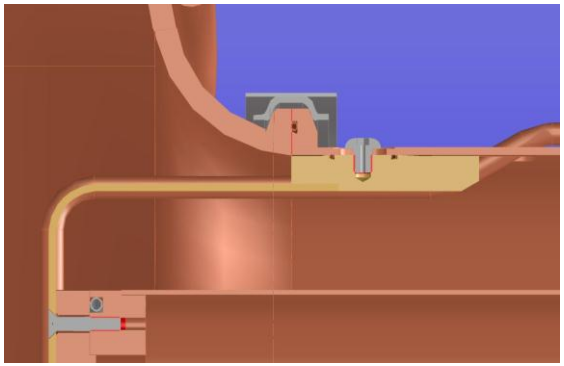
- Responsibility shared between two institutions
  - LBNL responsible for cavities [D. Li]
    - as part of RFCC modules
  - Daresbury Lab responsible for RF power sources and distribution system [A. Moss]
    - refurbishing power sources (originally from LBNL and CERN)
    - planning for installation of power systems in Hall
    - planning coax distribution system from power source to cavity

- Shared responsibility implies need for careful attention to interface issues

# RF Cavity Status (1)

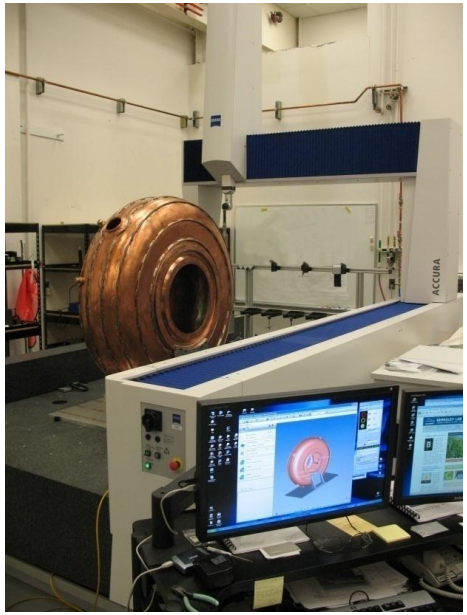
- **Complete or in progress**
  - TiN-coated Be windows (11) available for RFCC-1
  - ceramic RF windows (10) delivered
  - first set of 6 tuner arms in production at Fermilab
    - 6 actuators being fabricated
  - input coupler design improved (based on results from prototype test)
  - fixturing for electropolishing ready
    - awaiting ES&H approval to start (~1 month job to do 10 cavities)
  - single-cavity test vessel completed
    - delivery to Fermilab happens this month

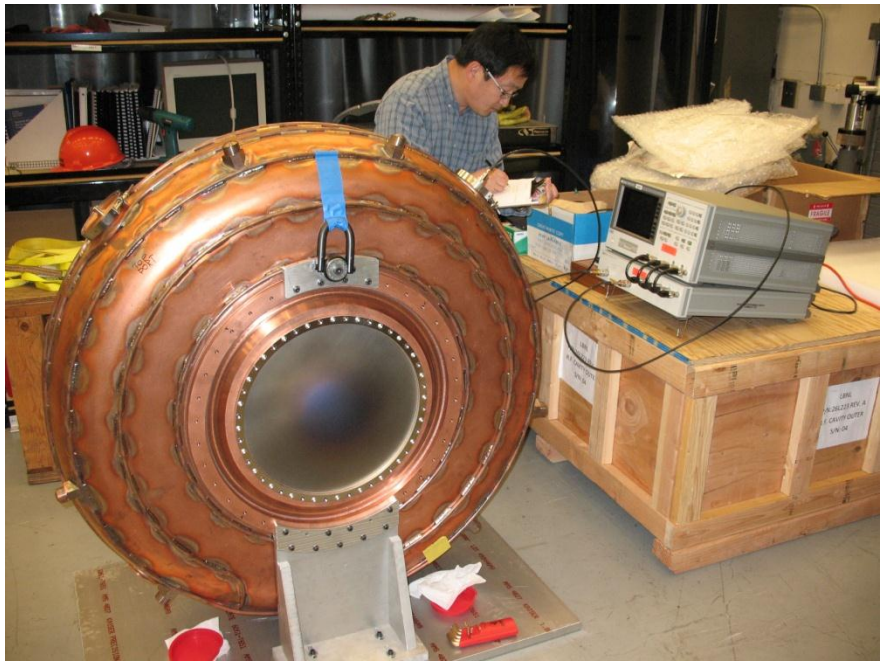




# RF Cavity Status (2)

- To be done
  - physical (CMM) measurements to document cavity shape
    - few weeks work
  - frequency measurements
    - all cavities will be deformed to reach central frequency of 201 MHz
  - RF conditioning (without and with magnetic field ⇒ await first CC)
- No unresolved issues (yet)





# RF Power Issues (1)

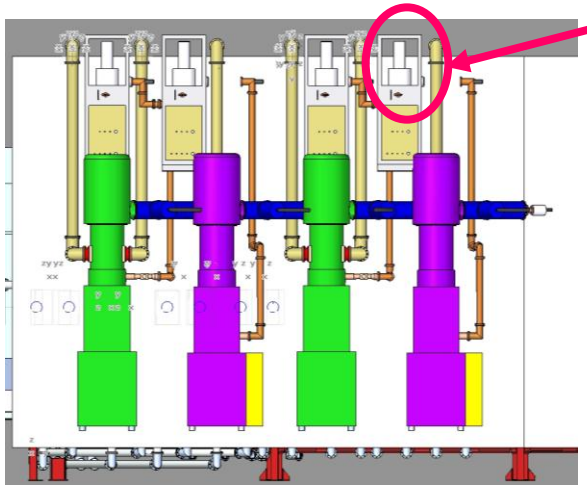
- First amplifier tested to 1 MW
  - test with new TH116 tube to 2 MW full power level remains to be done
    - need to get this finished!
  - worthwhile to understand whether output power could be higher
    - permits "headroom" for amplitude regulation
      - and expected loss of performance as tube ages
    - accommodates transmission losses
  - however, there is some risk involved in finding out
- Review committee (December '11) made a number of comments that merit our consideration
  - Moss to prepare response for comment by Tech Board
    - low tube lifetime (15K hrs at ISIS)
      - and imminent lack of supplier for additional tubes
    - need for headroom for control
    - maintenance challenge behind shield wall
    - amplifier sticks out above magnetic shield wall

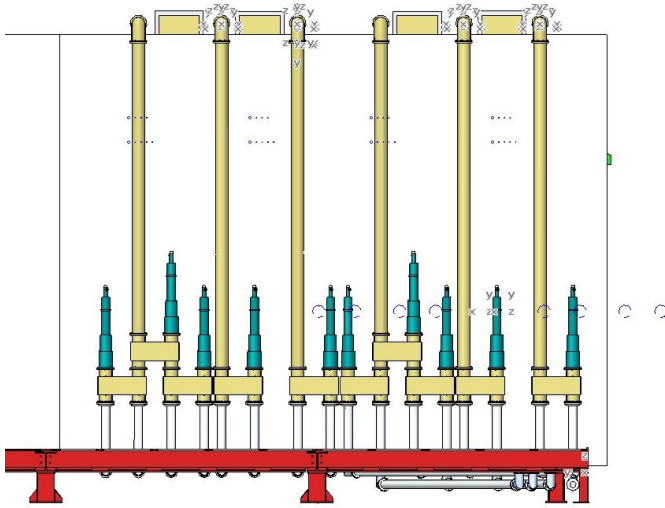
# RF Power Issues (2)

- **Other review comments**
  - concern expressed about 4-in. coax power handling capability
    - suggested testing system at MTA before ordering waveguide
  - concern that specifications for RF system undefined
  - suggested that adjustable phase shifters were unnecessary complication
- **Review comments and proposed responses discussed**
  - tube availability is a real issue, but not much can be done
    - have 4 tubes now (£45K)
    - have purchased spare glass tubes as insurance
  - tube degradation information at 50 Hz (*vs.* MICE 1 Hz)
    - don't really know scaling, so some "exposure" here
      - not a go-no-go issue
  - control headroom not accounted for, nor losses in transmission thru coax
    - not clear whether we need this control (see later)
      - could be we get less than 2 MW to cavity (⇒ lower voltage)
        - or we cool cavities (not presently considered for routine operation)

# RF Power Issues (3)

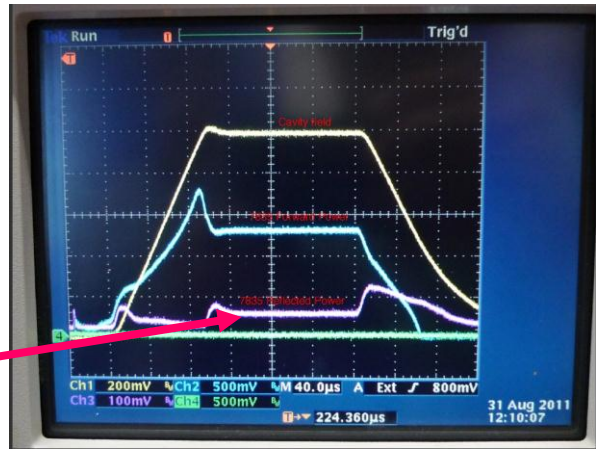
- **Proposed responses (cont'd)**
  - investigated removal of phase shifters
    - looks sensible; get ~2% loss of acceleration compared with optimum phase
    - simplifies the plumbing
      - relieving maintenance concern
    - likely improves operational reliability
  - cursory look at amplifier position indicates field should be modest
    - power supplies on mezzanine are another story





# RF Power Issues (4)

- Proposed responses (cont'd)
  - 4-in. coax should be okay with slow-fill ramp
    - much less reflected power (10%)
      - standard Fermilab operation mode
  - waiting for test not viewed as necessary
    - delay in order puts $ at risk
    - potentially disrupts MTA program



reflected power

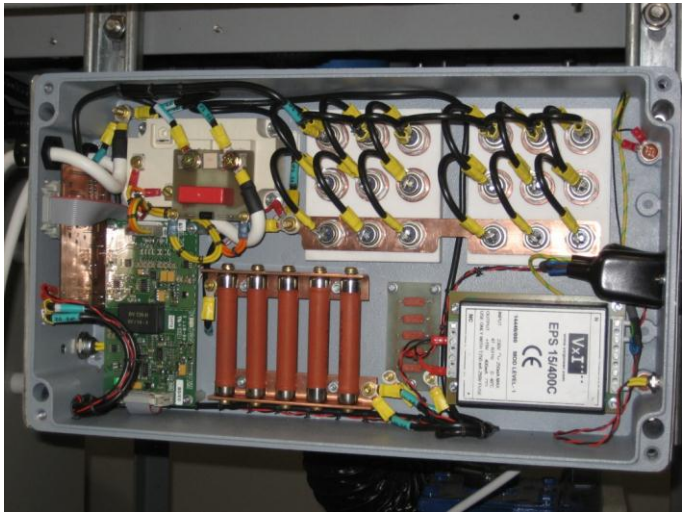
- Issues raised at this meeting
  - check whether more bellows are needed to simplify coax installation
  - check CAD model to make sure latest RFCC is used
  - need to start on LLRF design
    - have DL people to do this
      - need help from LBNL (Doolittle)
  - need better understanding of MICE requirements (timing; stability; …)

# RF Control & Monitoring

- **Most hardware needed for first system built and tested now**
  - **test to 2 MW in March 2012**
  - **on track for full test at RAL in Sept. 2013**
- **Desire to have second system available at DL *before* sending system 1 to RAL**
  - **at risk due to "cash-flow" problems**
    - **need to define "drop-dead" date for purchases to stay off of critical path**

20 kV PSU & Aux. rack – front view

Modulator (operational)



# Testing Issues

- Prudent to test full system after delivery to RAL
  - desirable to duplicate MTA single-cavity vacuum vessel at RAL
    - will minimize disruptions to MTA
- Not obvious (to me) that test of coax at MTA is justified
- Prudent to carefully test amplifier above 2 MW
  - compensation for losses
  - headroom for control
    - measurements of amplitude and phase jitter are valuable
- MUST understand, document, and demonstrate specifications of system
  - needed for LLRF design
  - Li and Moss propose timing workshop to get requirements (before CM33)
  - need general RF parameter discussion/workshop
    - phase and amplitude stability requirements
      - and means to achieve them

# Schedule (1)

- **Planned schedule for RF power**

## Current work in progress:

- RF testing of System #1 with new 4616 and TH116 tubes — Nov 11 to Mar 12

## Future work (Step V): time-scales to be confirmed

- Assembly of CERN TH116 amplifier (System #2) ---------- (July 2012)
- Test CERN amplifier at Daresbury ---------- (December 2012)
- Develop RF Control Systems
- Pack & ship complete system #1 to RAL ---------- (January 2013)
- Install RF System #1 in MICE Hall ---------- (May 2013)
- Test complete RF system #1 at RAL ---------- (September 2013)
- Construct & test 4616 #2 amplifier, power supply & controls
- Construct & test TH116 #2 power supply & controls
- Test complete RF system #2 at DL
- Pack & ship system #2 to RAL
- Install RF System #2 in MICE Hall
- Test complete RF system #2 at RAL

Tasks in red are required for TIARA (deadline in brackets)

# Schedule (2)

- RF cavity cleaning should begin shortly
  - about 1 month job
- Single-cavity vacuum vessel fabrication complete
  - delivery to Fermilab this month
    - can test/process cavity to full field without B field
      - repeat with CC when ready
    - tests tuner mechanism and thermal performance
    - could test LN-temperature operation
      - risky, so do not use best cavity for this
  - open question: how many MICE cavities should be tested

# Summary

- Steady progress on all aspects of RF system
  - RF power system review very valuable
    - responses should be reviewed by Tech Board before finalizing
    - need to separate required testing from "feel-good" testing
    - explore risks/benefits of testing above 2 MW
- Time to get serious about specifications
  - timing workshop and detailed parameter discussions should happen prior to CM33
    - important to have one RF group, not two half-groups
- Desirable to have complete second power system at DL before first system ships to RAL
- Desirable to have second single-cavity test vessel at RAL